

ANAMORPHIC CONVERTER

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to an anamorphic converter suitable for a film camera, a television camera, a video camera or the like which is disposed on an image side of an imaging optical system in order to convert an aspect ratio to photograph an
10 image having an aspect ratio different from that of an image pickup element, a lens device using the same, and an image pickup device such as a film camera, a television camera, or a video camera using the same.

Related Background Art

15 As a technique for converting an aspect ratio of an image to record and reproduce the resultant image, up to this time, various techniques have been proposed. In particular, for use in a motion picture, a system in which an image is optically compressed
20 horizontally using an anamorphic lens to be photographed on a film, and during the reproduction, the image on the film is optically horizontally magnified to be projected using an anamorphic lens as well is generally used as a system for recording and
25 reproducing an image in compliance with the CinemaScope form having an aspect ratio of 2.35 : 1. As an anamorphic converter, a large number of front

converters each mounted on a side of an object of an imaging optical system were proposed (refer to Japanese Patent Application Laid-Open Nos. 48-24048, 2-13916, 3-25407, 5-188271, 5-188272, 6-82691 and
5 Japanese Patent No. 2,817,074 for example).

In addition, a rear converter mounted to an image side of an imaging optical system was proposed (refer to Japanese Patent No. 3,021,985 for example).

In recent years, promotion of high image
10 quality of the video technique has progressed, and a digital cinema system for making a film of a scene with an HDTV (High Definition Television) system is in the progress of being popularized. In a digital cinema system, an image pickup element having an
15 aspect ratio of 16 : 9 (1.78 : 1) is generally used. However, for the photographing complying with the CinemaScope form having the aspect ratio of 2.35 : 1, there has been demanded an anamorphic converter for effectively utilizing pixels on an image pickup
20 element to enhance image quality.

It is required for an anamorphic converter for the cinema that the suitable aspect ratio conversion is made, no eclipse is generated, an effective image surface of an imaging optical system can be
25 sufficiently utilized, reduction in a quantity of marginal ray is less, and high optical performance is provided throughout zooming and focusing.

As described in Japanese Patent Application Laid-Open Nos. 2-13916, 6-82691, and Japanese Patent No. 2,817,074, the front converter type has advantages that a structure is simple, and an effective diameter is ensured irrespective of a conversion ratio to avoid generation of the eclipse. On the other hand, there is encountered a problem that the size is large, and a change in astigmatism due to focusing occurs.

10 In addition, as a technique for correction of astigmatism due to focusing, there were proposed the techniques described in Japanese Patent Application Laid-Open Nos. 48-24048, 3-25407, 5-188271 and 5-188272. In these techniques, however, there is encountered a problem that correction means within a converter must be driven in conjunction with focusing in an imaging optical system, and hence a complicated mechanism is required.

20 The rear converter type has an advantage that there occurs no change in astigmatism due to focusing. However, a problem arises that when a conversion magnification on a vertical side and a conversion magnification are not suitably set, the eclipse is generated and a field angle of an imaging optical system is changed so that an effective image surface can not be sufficiently utilized.

As the rear converter type, there are a system

having no primary image formation as shown in FIG. 31, and a system having primary image formation as shown in FIG. 32.

In FIGS. 31 and 32, α_1 is an emission inclination angle of axial marginal ray from an imaging optical system, and α_2 and α_3 are emission inclination angles of axial marginal ray from an anamorphic converter AC.

In case of the rear converter type having no primary image formation, as shown in FIG. 31, an axial marginal ray from the imaging optical system needs to be made nearly afocal with a negative lens. At the same time, since an off-axial chief ray is leapt up, an off-axial chief ray emission height hb_2 from a converter final surface becomes large. Hence, a problem occurs that vignetting is increased to reduce a quantity of axial marginal ray, and an off-axial chief ray emission inclination angle α_{b2} is increased to shorten an exit pupil, and thus an influence of the color shading by a color separation optical system becomes easy to be generated.

The system having no primary image formation, i.e., the rear converter in which both focal length conversion magnifications β_x and β_y are positive values is proposed in JP 3,021,985 B. In this case, however, since the rear converter is prescribed so that a positive refracting power is obtained in a

horizontal direction, and a negative refracting power is obtained in a vertical direction, the rear converter has an effect of lengthening a focal length in addition to an effect of converting an aspect ratio. As a result, there is a problem that a field angle becomes narrow, and if the field angle is tried to be ensured, then an image pickup means having a larger image size is required, and if the image pickup means having the larger image size is used, then an exit pupil position becomes relatively short so that an exit angle of an off-axial chief ray of a peripheral portion of a screen becomes large, and hence the shading or the like is generated.

15 SUMMARY OF THE INVENTION

In the light of the foregoing, it is an object of the present invention to provide an anamorphic converter of a rear converter system which is especially most suitable for a converter for the cinema, and which is miniature and excellent in optical performance.

According to a first aspect of the present invention, there is provided an anamorphic converter including at least an anamorphic lens disposed on an image side of an imaging optical system,

in which when a focal length conversion magnification in an arbitrary cross section X

containing an optical axis of the anamorphic converter is assigned β_x , a focal length conversion magnification in a cross section Y containing an optical axis and being perpendicular to the cross section X is assigned β_y , an aspect ratio of an image pickup range in an image surface of the imaging optical system is assigned AR1, and an aspect ratio of an effective area of image pickup means is assigned AR2, the following relationship is established:

$$0.9 < (AR1 \times \beta_x) / (AR2 \times \beta_y) < 1.1$$

According to a second aspect of the present invention, in the anamorphic converter according to the first aspect of the invention, the anamorphic lens is provided within an afocal group.

According to a third aspect of the present invention, in the anamorphic converter according to the first aspect of the invention, both β_x and β_y are positive values, and the anamorphic converter has positive refracting powers in the cross section X and in the cross section Y.

According to a fourth aspect of the present invention, the anamorphic converter according to the third aspect of the invention further includes, from the imaging optical system side in a stated order, a first group of lenses having a negative refracting power, a second group of lenses including at least

two or more anamorphic lenses, and a third group of lenses having a positive refracting power.

According to a fifth aspect of the present invention, in the anamorphic converter according to the third aspect of the invention, the following relationship is established:

$$1 \leq (AR2^2 + 1) \times \beta_y / (AR1^2 + 1) < 2.6$$

According to a sixth aspect of the present invention, in the anamorphic converter according to the first aspect of the invention, both β_x and β_y are negative values, and the anamorphic converter further includes at least one negative lens and two or more anamorphic lenses.

According to a seventh aspect of the present invention, there is provided an anamorphic converter including at least an anamorphic lens disposed on an image side of an imaging optical system,

in which when a focal length conversion magnification in an arbitrary cross section X containing an optical axis of the anamorphic converter is assigned β_x , and a focal length conversion magnification in a cross section Y containing an optical axis and being perpendicular to the cross section X is assigned β_y , both β_x and β_y are negative values.

According to an eighth aspect of the present invention, there is provided a lens device,

including:

the anamorphic converter according to any one
of the first to seventh aspects of the invention; and
the imaging optical system disposed on an
5 object side with respect to the anamorphic converter.

According to a ninth aspect of the present
invention, there is provided an image pickup device,
including:

the anamorphic converter according to any one
10 of the first to seventh aspects of the invention;
an imaging optical system disposed on an object
side with respect to the anamorphic converter; and
image pickup means disposed on the object side
with respect to the anamorphic converter.

15 According to a tenth aspect of the present
invention, there is provided an anamorphic converter
including at least an anamorphic lens disposed on an
image side of an imaging optical system,

in which when a focal length conversion
20 magnification in an arbitrary cross section X
containing an optical axis of the anamorphic
converter is assigned β_x , a focal length conversion
magnification in a cross section Y containing an
optical axis and being perpendicular to the cross
25 section X is assigned β_y , an aspect ratio of an image
pickup range in an image surface of the imaging
optical system is assigned AR_1 , and an aspect ratio

of an effective area of image pickup means is assigned AR2, the following relationships are established:

$$0.9 < (AR1 \times \beta_x) / (AR2 \times \beta_y) < 1.1$$

5 $(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) < 1$

According to an eleventh aspect of the present invention, in the anamorphic converter according to the tenth aspect of the invention, the anamorphic lens is provided within an afocal group.

10 According to a twelfth aspect of the present invention, in the anamorphic converter according to the tenth aspect of the invention, both β_x and β_y are positive values, and the anamorphic converter has positive refracting powers in the cross section X and
15 in the cross section Y.

According to a thirteenth aspect of the present invention, the anamorphic converter according to the twelfth aspect of the invention further includes, from the imaging optical system side in a stated
20 order, a first group of lenses having a negative refracting power, a second group of lenses including at least two or more anamorphic lenses, and a third group of lenses having a positive refracting power.

According to a fourteenth aspect of the present
25 invention, in the anamorphic converter according to the tenth aspect of the invention, both β_x and β_y are negative values, and the anamorphic converter further

includes at least one negative lens and two or more anamorphic lenses.

According to a fifteenth aspect of the present invention, there is provided a lens device,
5 including:

the anamorphic converter according to any one of the tenth to fourteenth aspects of the invention; and

the imaging optical system disposed on an
10 object side with respect to the anamorphic converter.

According to a sixteenth aspect of the present invention, there is provided an image pickup device, including:

the anamorphic converter according to any one
15 of the tenth to fourteenth aspects of the invention;

the imaging optical system disposed on an object side with respect to the anamorphic converter; and

image pickup means disposed on the object side
20 with respect to the anamorphic converter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a wide angle end of Numerical Example 1 in an X direction
25 and in a Y direction;

FIG. 2 is a longitudinal aberration view of Numerical Example 1 in the X direction under a

condition in which f_x is 9.7 mm, f_y is 12.9 mm, and an object distance is 2.5 m;

FIG. 3 is a longitudinal aberration view of Numerical Example 1 in the Y direction under a
5 condition in which f_x is 9.7 mm, f_y is 12.9 mm, and an object distance is 2.5 m;

FIG. 4 is a longitudinal aberration view of Numerical Example 1 in the X direction under a
condition in which f_x is 37.3 mm, f_y is 49.3 mm and
10 the object distance is 2.5 m;

FIG. 5 is a longitudinal aberration view of Numerical Example 1 in the Y direction under a
condition in which f_x is 37.3 mm, f_y is 49.3 mm and the object distance is 2.5 m;

15 FIG. 6 is a longitudinal aberration view of Numerical Example 1 in the X direction under a
condition in which f_x is 142.9 mm, f_y is 189.0 mm and the object distance is 2.5 m;

FIG. 7 is a longitudinal aberration view of
20 Numerical Example 1 in the Y direction under a
condition in which f_x is 142.9 mm, f_y is 189.0 mm and the object distance is 2.5 m;

FIG. 8 is a cross sectional view of a wide angle end of Numerical Example 2 in the X direction
25 and in the Y direction;

FIG. 9 is a longitudinal aberration view of Numerical Example 2 in the X direction under a

condition in which f_x is 9.7 mm, f_y is 12.9 mm and the object distance is 2.5 m;

FIG. 10 is a longitudinal aberration view of Numerical Example 2 in the Y direction under a
5 condition in which f_x is 9.7 mm, f_y is 12.9 mm and the object distance is 2.5 m;

FIG. 11 is a longitudinal aberration view of Numerical Example 2 in the X direction under a
condition in which f_x is 37.3 mm, f_y is 49.3 mm and
10 the object distance is 2.5 m;

FIG. 12 is a longitudinal aberration view of Numerical Example 2 in the Y direction under a
condition in which f_x is 37.3 mm, f_y is 49.3 mm and
the object distance is 2.5 m;

15 FIG. 13 is a longitudinal aberration view of Numerical Example 2 in the X direction under a
condition in which f_x is 142.9 mm, f_y is 189.0 mm and the object distance is 2.5 m;

FIG. 14 is a longitudinal aberration view of
20 Numerical Example 2 in the Y direction under a
condition in which f_x is 142.9 mm, f_y is 189.0 mm and the object distance is 2.5 m;

FIG. 15 is a conceptual diagram of an aspect ratio;

25 FIG. 16 is a conceptual diagram of an image circle and an image pickup range in an image surface of an imaging optical system;

FIG. 17 is a conceptual diagram of an image circle and an image pickup range after conversion made by a converter of the present invention;

FIG. 18 is a conceptual diagram of an effective
5 area of an image pickup means;

FIG. 19 is a conceptual diagram of a display area of an output image in projecting an image;

FIG. 20 is a cross sectional view in a wide angle end before insertion of an anamorphic converter
10 of Numerical Examples 1, 2, and 3;

FIG. 21 is a longitudinal aberration view under a condition in which f is 10.3 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 1, 2, and 3;

15 FIG. 22 is a longitudinal aberration view under a condition in which f is 39.5 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 1, 2, and 3;

FIG. 23 is a longitudinal aberration view under
20 a condition in which f is 151.1 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 1, 2, and 3;

FIG. 24 is a cross sectional view in a wide angle end of Numerical Example 3 in the X direction
25 and in the Y direction;

FIG. 25 is a longitudinal aberration view of Numerical Example 3 in the X direction under a

condition in which f_x is -9.7 mm, f_y is -12.9 mm and the object distance is 2.5 m;

FIG. 26 is a longitudinal aberration view of Numerical Example 3 in the Y direction under a
5 condition in which f_x is -9.7 mm, f_y is -12.9 mm and the object distance is 2.5 m;

FIG. 27 is a longitudinal aberration view of Numerical Example 3 in the X direction under a
condition in which f_x is -37.3 mm, f_y is -49.3 mm and
10 the object distance is 2.5 m;

FIG. 28 is a longitudinal aberration view of Numerical Example 3 in the Y direction under a
condition in which f_x is -37.3 mm, f_y is -49.3 mm and
the object distance is 2.5 m;

15 FIG. 29 is a longitudinal aberration view of Numerical Example 3 in the X direction under a
condition in which f_x is -142.9 mm, f_y is -189.0 mm and the object distance is 2.5 m;

FIG. 30 is a longitudinal aberration view of
20 Numerical Example 3 in the Y direction under a
condition in which f_x is -142.9 mm, f_y is -189.0 mm and the object distance is 2.5 m;

FIG. 31 is a conceptual view of an anamorphic converter of a type having no primary image
25 formation;

FIG. 32 is a conceptual view of an anamorphic converter of a type having primary image formation;

FIG. 33 is a cross sectional view in a wide angle end of Numerical Example 4 in the X direction and in the Y direction;

FIG. 34 is a longitudinal aberration view of
5 Numerical Example 4 in the X direction under a condition in which f_x is 7.90 mm, f_y is 10.44 mm and the object distance is 2.5 m;

FIG. 35 is a longitudinal aberration view of Numerical Example 4 in the Y direction under a
10 condition in which f_x is 7.90 mm, f_y is 10.44 mm and the object distance is 2.5 m;

FIG. 36 is a longitudinal aberration view of Numerical Example 4 in the X direction under a condition in which f_x is 30.24 mm, f_y is 39.98 mm and
15 the object distance is 2.5 m;

FIG. 37 is a longitudinal aberration view of Numerical Example 4 in the Y direction under a condition in which f_x is 30.24 mm, f_y is 39.98 mm and the object distance is 2.5 m;

20 FIG. 38 is a longitudinal aberration view of Numerical Example 4 in the X direction under a condition in which f_x is 115.83 mm, f_y is 153.12 mm and the object distance is 2.5 m;

FIG. 39 is a longitudinal aberration view of
25 Numerical Example 4 in the Y direction under a condition in which f_x is 115.83 mm, f_y is 153.12 mm and the object distance is 2.5 m;

FIG. 40 is a cross sectional view in a wide angle and of Numerical Example 5 in the X direction and in the Y direction;

FIG. 41 is a longitudinal aberration view of Numerical Example 5 in the X direction under a condition in which f_x is 7.34 mm, f_y is 9.71 mm and the object distance is 2.5 m;

FIG. 42 is a longitudinal aberration view of Numerical Example 5 in the Y direction under a condition in which f_x is 7.34 mm, f_y is 9.71 mm and the object distance is 2.5 m;

FIG. 43 is a longitudinal aberration view of Numerical Example 5 in the X direction under a condition in which f_x is 28.12 mm, f_y is 37.18 mm and the object distance is 2.5 m;

FIG. 44 is a longitudinal aberration view of Numerical Example 5 in the Y direction under a condition in which f_x is 28.12 mm, f_y is 37.18 mm and the object distance is 2.5 m;

FIG. 45 is a longitudinal aberration view of Numerical Example 5 in the X direction under a condition in which f_x is 107.72 mm, f_y is 142.41 mm and the object distance is 2.5 m;

FIG. 46 is a longitudinal aberration view of Numerical Example 5 in the Y direction under a condition in which f_x is 107.72 mm, f_y is 142.41 mm and the object distance is 2.5 m;

FIG. 47 is a conceptual diagram of an aspect ratio;

FIG. 48 is a conceptual diagram of an image circle and an image pickup range in an image surface
5 of a main lens;

FIG. 49 is a conceptual diagram of an image circle and an image pickup range after conversion made by a converter of the present invention;

FIG. 50 is a conceptual diagram of an effective
10 area of an image pickup means;

FIG. 51 is a conceptual diagram of a display area of an output image in projecting an image;

FIG. 52 is a cross sectional view in a wide angle end before insertion of an anamorphic converter
15 of Numerical Examples 4, 5, and 6;

FIG. 53 is a longitudinal aberration view under a condition in which f is 10.3 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 4, 5, and 6;

20 FIG. 54 is a longitudinal aberration view under a condition in which f is 39.5 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 4, 5, and 6;

FIG. 55 is a longitudinal aberration view under
25 a condition in which f is 151.1 mm and the object distance is 2.5 m before insertion of the anamorphic converter of Numerical Examples 4, 5, and 6;

FIG. 56 is a cross sectional view in a wide angle end of Numerical Example 6 in the X direction and in the Y direction;

FIG. 57 is a longitudinal aberration view of
5 Numerical Example 6 in the X direction under a condition in which f_x is -7.11 mm, f_y is -9.40 mm and the object distance is 2.5 m;

FIG. 58 is a longitudinal aberration view of
Numerical Example 6 in the Y direction under a
10 condition in which f_x is -7.11 mm, f_y is -9.40 mm and the object distance is 2.5 m;

FIG. 59 is a longitudinal aberration view of
Numerical Example 6 in the X direction under a
condition in which f_x is -27.25 mm, f_y is -36.01 mm
15 and the object distance is 2.5 m;

FIG. 60 is a longitudinal aberration view of
Numerical Example 6 in the Y direction under a
condition in which f_x is -27.25 mm, f_y is -36.01 mm
and the object distance is 2.5 m;

20 FIG. 61 is a longitudinal aberration view of
Numerical Example 6 in the X direction under a
condition in which f_x is -104.37 mm, f_y is -137.96 mm
and the object distance is 2.5 m;

FIG. 62 is a longitudinal aberration view of
25 Numerical Example 6 in the Y direction under a
condition in which f_x is -104.37 mm, f_y is -137.96 mm
and the object distance is 2.5 m;

FIG. 63 is a conceptual view of an anamorphic converter of a type having no primary image formation; and

FIG. 64 is a conceptual view of an anamorphic
5 converter of a type having primary image formation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Operation 1)

Aspect 1

10 An anamorphic converter according to the present invention includes at least an anamorphic lens disposed on an image side of an imaging optical system, and the anamorphic converter is characterized in that when a focal length conversion magnification
15 in an arbitrary cross section X containing an optical axis of the anamorphic converter is assigned β_x , a focal length conversion magnification in a cross section Y containing an optical axis and being perpendicular to the cross section X is assigned β_y ,
20 an aspect ratio of an image pickup range in an image surface of the imaging optical system is assigned AR1, and an aspect ratio of an effective area of image pickup means is assigned AR2, the following relationship is established:

25
$$0.9 < (AR1 \times \beta_x) / (AR2 \times \beta_y) < 1.1$$

Aspect 1 is concerned with a condition under which the conversion magnification of the anamorphic

converter is suitably prescribed to thereby carry out the suitable conversion of an aspect ratio without generation of an eclipse.

Equation 1 exhibits with a condition under
5 which the suitable aspect ratio conversion is carried out. When as shown in FIG. 15, a transverse length of an image surface is assigned X, a longitudinal length of the image surface is assigned Y, an aspect ratio AR is expressed by Equation 2:

10
$$AR = X/Y \quad (2)$$

A schematic diagram of an image pickup range of an imaging optical system is shown in FIG. 16, and a schematic diagram of an image pickup range of an image pickup means is shown in FIG. 17. When from
15 FIG. 16, a transverse length of a size of an effective picture of the image pickup range in the image surface of the imaging optical system is assigned X1, a longitudinal length of the size of that effective picture is assigned Y1, and an aspect ratio is assigned AR1, and from FIG. 17, a transverse
20 length of the image pickup range of the image pickup means is assigned X2, a longitudinal length of that image pickup range is assigned Y2, and an aspect ratio is assigned AR2, a ratio of AR1/AR2 is
25 expressed by Equation 3:

$$AR1/AR2 = (X1 \times Y2)/(X2 \times Y1) \quad (3)$$

In addition, a conceptual diagram of an image pickup

range after the conversion of the aspect ratio made by the anamorphic converter is shown in FIG. 18. In order that the aspect ratio may be suitably converted, it is desirable that a conversion magnifications β_x of the anamorphic converter in a transverse direction, and a conversion magnification β_y of the anamorphic converter in a longitudinal direction are expressed by Equations 4 and 5, respectively:

$$\beta_x = X_2/X_1 \quad (4)$$

$$\beta_y = Y_2/Y_1 \quad (5)$$

From Equations 3 to 5, the condition for ideal aspect ratio conversion is expressed as follows:

$$(AR_1 \times \beta_x) / (AR_2 \times \beta_y) = 1 \quad (6)$$

Since in actual, an influence of an error of about 10% is visually small, Equation 1 is met to thereby allow the suitable aspect ratio conversion to be realized.

Also, a conceptual diagram of an output image in projecting an image is shown in FIG. 19. It is necessary that in projecting an image, the conversion of the aspect ratio reverse to that in capturing an image is carried out to return the current aspect ratio back to the original aspect ratio.

Consequently, a transverse length X_4 and a longitudinal length Y_4 in FIG. 19 are expressed as follows, respectively:

$$X_4 = \beta_x' \times X_2 \quad (7)$$

$$Y4 = \beta y' \times Y2 \quad (8)$$

Here, the conversion magnifications $\beta x'$ and $\beta y'$, when an arbitrary constant is assigned m , are expressed as follows, respectively:

5 $\beta x' = m/\beta x \quad (9)$

$$\beta y' = m/\beta y \quad (10)$$

Aspect 2

There is provided an anamorphic converter according to Aspect 1, in which the anamorphic lens
10 is provided within an afocal group.

Aspect 3

There is provided an anamorphic converter according to Aspect 1 or 2, characterized in that both βx and βy are positive values, and the
15 anamorphic converter has positive refracting powers in the cross section X and in the cross section Y.

Aspect 4

There is provided an anamorphic converter according to Aspect 3, further including, from the
20 imaging optical system side in a stated order, a first group of lenses having a negative refracting power, a second group of lenses including at least two or more anamorphic lenses, and a third group of lenses having a positive refracting power.

25 Aspect 5

There is provided an anamorphic converter according to Aspect 3 or 4, characterized in that the

following relationship is established:

$$1 \leq (AR_2^2 + 1) \times \beta_y^2 / (AR_1^2 + 1) < 2.6 \quad (11)$$

Aspect 4 is concerned with a condition under which the power disposition of the anamorphic
5 converter for carrying out the aspect ratio conversion without the primary image formation by an imaging optical system is suitably prescribed to make the optical performance excellent.

In order that the primary imaging may be
10 prevented from being made, it is necessary that both the focal length conversion magnifications β_x and β_y are positive values. Moreover, the cross section X and the cross section Y have positive refracting powers, respectively, to thereby reduce the effect of
15 lengthening a focal length. As a result, there is obtained the anamorphic converter of a type having no primary image formation in which for the single imaging optical system, the field angle is prevented from becoming too narrow, and the exit pupil can be
20 held for long.

In Aspect 4, the suitable structure in Aspect 3 is prescribed. In order that the cross section X and the cross section Y may have different conversion magnifications, it is necessary to form an afocal
25 converter (anamorphic converter) having different angular magnifications in the cross section X and the cross section Y by using at least two so-called toric

lenses each having different curvatures in the cross section X and the cross section Y, or at least two cylindrical lenses having a curvature in a certain cross section. In addition, in order that the
5 converter may be disposed on an image side of the imaging optical system, there are required a first group of lenses having a negative refracting power for causing a converged ray from the imaging optical system to diverge, and a group of lenses having a
10 positive refracting power for imaging that ray. Consequently, an optical property of a portion between the first group of lenses having a negative refracting power and the group of lenses having a positive refracting power is made nearly afocal, and
15 a group of lenses including an anamorphic lens is introduced as the second group of lenses, whereby it is possible to attain an anamorphic converter having no primary image formation.

In Aspect 5, there is prescribed a relationship
20 among the focal length conversion magnification β_y , and the aspect ratios AR1 and AR2 for preventing the field angle from becoming too narrow while preventing generation of the eclipse in Aspect 3 or Aspect 4.

Equation (11) exhibits a condition under which
25 reduction in the field angle is suppressed while preventing generation of the eclipse following the aspect ratio conversion. When the converter is

disposed on an image side of the imaging optical system, since an image circle is regulated on the basis of the effective diameter on the side of the imaging optical system, the wide angle can not be
5 obtained even if the conversion magnification is made smaller than 1. Consequently, the eclipse is generated in the periphery of the picture.

As shown in FIG. 16, an image circle I1 of the imaging optical system is expressed by Equation 12:

10
$$I1 = (X1^2 + Y1^2)^{1/2} = Y1 \times (AR1^2 + 1)^{1/2} \quad (12)$$

In addition, as shown in FIG. 17, a width I2 across corners of the image pickup means is expressed by Equation 13:

$$I2 = (X2^2 + Y2^2)^{1/2}$$

15
$$= \beta y \times Y1 \times (AR2^2 + 1)^{1/2} \quad (13)$$

Here, as shown in FIG. 18, a width I3 across corners of the image which is subjected to the aspect ratio conversion in the anamorphic converter is expressed by Equation 14:

20
$$I3 = \{(\beta x \times X1)^2 + (\beta y \times Y1)^2\}^{1/2}$$
$$= \beta y \times Y1 \times (AR2^2 + 1)^{1/2} \quad (14)$$

Consequently, in order that the image after the aspect ratio conversion may contain the width across corners of the image pickup means to prevent
25 generation of the eclipse, a relationship of $I3 \geq I2$ must be established. Thus, from Equations 13 and 14, Equations 15 and 11-2 are obtained:

$$I_3^2/I_2^2 \geq 1 \quad (15)$$

$$\{\beta_y^2 \times (AR_2^2 + 1)\}/(AR_1^2 + 1) \geq 1 \quad (11-2)$$

As a result, if the lower limit in Equation (11) is exceeded, the eclipse will be generated.

5 In addition, if the upper limit in Equation 11 is exceeded, then the field angle obtained through the conversion made by the converter becomes narrower than that in the single imaging optical system, so that the image pickup range of the imaging optical
10 system becomes unable to be effectively utilized.

Aspect 6

There is provided an anamorphic converter according to Aspect 1 or 2, in which both β_x and β_y are negative values, and the anamorphic converter
15 includes at least one negative lens and two or more anamorphic lenses.

Aspect 7

There is provided an anamorphic converter including at least an anamorphic lens disposed on an
20 image side of an imaging optical system, in which when a focal length conversion magnification in an arbitrary cross section X containing an optical axis of the anamorphic converter is assigned β_x , and a focal length conversion magnification in a cross
25 section Y containing an optical axis and being perpendicular to the cross section X is assigned β_y , both β_x and β_y are negative values.

Aspects 6 and 7 are concerned with a condition in which a structure of the anamorphic converter for obtaining the primary image formation through the imaging optical system to convert the aspect ratio is
5 suitably prescribed to make the optical performance excellent.

A conceptual view of the anamorphic converter of a type having primary image formation is shown in FIG. 32. For the optical system for reimaging the
10 primary image of the imaging optical system, it is necessary that both the focal length conversion magnifications β_x and β_y are negative values. In addition, in order to contain the marginal ray of the imaging optical system, it is necessary that an
15 entrance pupil nearly agrees with the exit pupil of the imaging optical system. Lenses for broadcasting including a lens for a digital cinema become an optical system which has a long exit pupil and hence is nearly telecentric on the image side since they
20 are established on the assumption that the color separation optical system is used. Consequently, an optical system which is at least nearly telecentric on the both sides is required for the converter. As shown in FIG. 32, in case of the anamorphic converter
25 of a type having primary image formation, since an emitted ray from the imaging optical system is made nearly afocal using the positive lens, an increase in

an off-axial chief ray emitted height hb_3 from the converter final surface is suppressed to prevent a quantity of marginal light from being reduced. Thus, an off-axial chief ray emitted inclination angle αb_3 can be made small. As a result, there is an advantage that the exit pupil becomes long, and hence an influence of the color shading due to the color separation optical system is hardly generated. As shown in FIG. 32, from the condition in which the converter is telecentric on the both sides, the anamorphic converter of a type having primary image formation is constituted by at least two groups of positive lenses, and the refracting power of the whole converter takes a minute value in the vicinity of zero.

In addition, since for the primary image obtained through the imaging optical system, the various aberrations such as the chromatic aberration, the antigmatism and the curvature of field are satisfactorily corrected, the chromatic aberration, the antigmatism, the curvature of field and the like of the converter must also be satisfactorily corrected. When a refracting power of an i -th lens of lenses within the converter is assigned Φ_i , an Abbe's number of the i -th lens of the lenses is assigned v_i , and a refracting index of the i -th lens of the lenses is assigned N_i , a chromatic aberration

correction condition is expressed as follows:

$$\Sigma(\Phi_i/v_i) \approx 0 \quad (16)$$

Also, a Petzval's condition is expressed as follows:

$$\Sigma(\Phi_i/N_i) \approx 0 \quad (17)$$

5 Here, since in the general optical materials, $v_i > 0$
and $N_i > 0$ are established, in order to meet
Equations (16) and (17), the anamorphic converter
having primary image formation must have at least an
negative lens in terms of its structure. Moreover,
10 any one of the intervals within the converter is made
nearly afocal, and the lens group including the
above-mentioned anamorphic lens is introduced,
whereby it is possible to attain the anamorphic
converter of a primary image formation type.

15 Aspect 8

There is provided a lens device, including: the
anamorphic converter according to any one of Aspects
1 to 7; and the imaging optical system disposed on an
object side with respect to the anamorphic converter.

20 Aspect 9

There is provided an image pickup device,
including: the anamorphic converter according to any
one of Aspects 1 to 8; an imaging optical system
disposed on an object side with respect to the
25 anamorphic converter; and image pickup means disposed
on the object side with respect to the anamorphic
converter.

The anamorphic lens used in the present invention is used in terms of the concept including a toric lens and a cylindrical lens, and hence means a lens in which a power in the X direction is different
5 from that in the Y direction.

In addition, the anamorphic lens used in the present invention may have a function of a diffraction system.

Moreover, the imaging optical system of the
10 present invention may be a variable power system or a fixed power system (having no variable power).
(First Embodiment)

This embodiment is concerned with an anamorphic converter of a type having no primary image formation.
15 FIG. 1 is a cross sectional view of lenses in a Y direction and in an X direction when an anamorphic converter is inserted in Numerical Example 1 of the present invention.

In addition, a cross sectional view before
20 insertion of the anamorphic converter in Numerical Example 1 is shown in FIG. 20.

FIGS. 21 to 23 show longitudinal aberration views before insertion of the anamorphic converter in Numerical Examples 1, 2, and 3, respectively.

25 In FIG. 1, reference symbol F designates a group of front focusing lenses having a positive refracting power as a first group. Reference symbol

V designates a variator for the variable power having a negative refracting power as a second group. The variator V is monotonously moved on an optical axis to an image surface side to thereby carry out the
5 variable power from the wide angle end to the telescopic end. Reference symbol C designates a compensator having a negative refracting power as a third group. The compensator C is nonlinearly moved on the optical axis to an object side while
10 describing a projection locus in order to compensate for the fluctuation of an image surface following the variable power. The variator V and the compensator C constitute the variable power system.

Reference symbol SP designates a stop, and
15 reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol P designates a color separation prism, an optical filter or the like which is shown in the form of a
20 glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
25 with respect to the feature of the anamorphic converter AC in Numerical Example 1. The anamorphic converter AC includes: a first group G1 of lenses

having a negative refracting power; a second group G2 of lenses having two cylindrical lenses; and a third group G3 of lenses having an image formation function and a positive refracting power. Each of the
5 cylindrical lenses belonging to the second group G2 has a curvature only in the X direction, and has an effect of shortening a focal length in the X direction. The aspect ratio AR1 of the image pickup range in the image surface of the imaging optical
10 system, and the aspect ratio AR2 of the effective area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (18)$$

$$AR2 = 1.78 \quad (19)$$

Also, the conversion magnification β_x in the X
15 direction, and the conversion magnification β_y in the Y direction are as follows:

$$\beta_x = 0.947 \quad (20)$$

$$\beta_y = 1.252 \quad (21)$$

Consequently, the values of the conditional equations
20 are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (22)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 1.00 \quad (23)$$

Thus, these values meet the conditions of Equations 1 and 11. Consequently, the anamorphic converter of a
25 built-in converter system is attained which is excellent in the optical performance and free from the eclipse.

In addition, in case of the single anamorphic converter AC, a focal length f_{ACx} in the X direction, and a focal length f_{ACy} in the Y direction are expressed as follows:

5 $f_{ACx} = +32.789$ (24)

$f_{ACy} = +69.848$ (25)

Thus, both of them have the positive refracting powers and hence meet the condition which is required for the anamorphic converter of the present invention.

10 A material of the cylindrical lens used in this embodiment is glass. In the following second and third embodiments as well, the same material will be used.

 FIGS. 2 to 7 are longitudinal aberration views
15 in the X direction or in the Y direction in Numerical Example 1. In these figures, f_x indicates a focal length in the X direction, f_y indicates a focal length in the Y direction, F_x indicates an F number in the X direction, F_y indicates an F number in the Y
20 direction, and 2ω indicates a field angle.

 In Numerical Example 1, the following values are obtained:

$f_x = 9.74$ to 142.93

$f_y = 12.88$ to 188.96

25 $F_x = 1.94$ to 2.19

$F_y = 2.56$ to 2.90

$2\omega = 56.2$ to 4.2 degrees

r 1=	1169.481		d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429		d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	265.170		d 3=	0.20				
r 4=	124.037		d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395		d 5=	0.20				
r 6=	51.797		d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915		d 7=	Variable				
r 8=	71.045		d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601		d 9=	6.01				
r10=	-21.542		d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397		d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134		d12=	Variable				
r13=	-27.245		d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613		d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345		d15=	Variable				
r16=	0.000	(Stop)	d16=	1.60				
r17=	10000.000		d17=	4.02	n10=	1.73234	v10=	54.7
r18=	-32.342		d18=	0.20				
r19=	107.938		d19=	3.60	n11=	1.48915	v11=	70.2
r20=	-121.402		d20=	0.20				
r21=	37.891		d21=	7.17	n12=	1.48915	v12=	70.2
r22=	-36.452		d22=	1.20	n13=	1.83932	v13=	37.2
r23=	177.431		d23=	30.00				
r24=	48.564		d24=	4.26	n14=	1.48915	v14=	70.2
r25=	-193.706		d25=	0.20				
r26=	-210.911		d26=	1.20	n15=	1.83932	v15=	37.2
r27=	39.960		d27=	6.49	n16=	1.48915	v16=	70.2
r28=	-33.683		d28=	0.20				
r29=	43.464		d29=	6.21	n17=	1.53430	v17=	48.8
r30=	-30.063		d30=	1.20	n18=	1.80811	v18=	46.6
r31=	113.246		d31=	0.20				
r32=	56.783		d32=	2.98	n19=	1.55098	v19=	45.8
r33=	-10000.000		d33=	2.40				
r34=	-7839.440		d34=	1.50	n20=	1.88815	v20=	40.8
r35=	23.812		d35=	11.72				
r36=	-53.891		d36=	1.50	n21=	1.88815	v21=	40.8
r37=	-398.617		d37=	0.20				
r38=	70.482		d38=	6.77	n22=	1.81264	v22=	25.4
r39=	-44.050		d39=	0.31				
r40=	-53.902		d40=	1.50	n23=	1.51825	v23=	64.1
r41=	63.160		d41=	13.52				
r42=	128.438		d42=	4.68	n24=	1.88815	v24=	40.8
r43=	80.144		d43=	0.20				
r44=	42.096		d44=	8.88	n25=	1.48915	v25=	70.2
r45=	-35.579		d45=	1.50	n26=	1.81264	v26=	25.4
r46=	357.584		d46=	0.20				
r47=	199.741		d47=	5.28	n27=	1.48915	v27=	70.2
r48=	46.226		d48=	2.00				
r49=	0.000		d49=	30.00	n28=	1.60718	v28=	38.0
r50=	0.000		d50=	16.20	n29=	1.51825	v29=	64.2
r51=	0.000							

* r40 to r43 indicate the cylindrical lenses. A curvature in the Y direction is zero.

Focal length fx	9.74	37.31	142.93
fy	12.88	49.33	188.96
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

(Second Embodiment)

This embodiment is concerned with an anamorphic
5 converter of a type having no primary image formation.

FIG. 8 is a cross sectional view of lenses in a
Y direction and in an X direction when an anamorphic
converter is inserted in Numerical Example 2 of the
present invention. In addition, a cross sectional
10 view before insertion of the anamorphic converter in
Numerical Example 2 is shown in FIG. 20.

In FIG. 8, reference symbol F designates a
group of front lenses having a positive refracting
power as a first group. Reference symbol V
15 designates a variator for the variable power having a
negative refracting power as a second group. The
variator V is monotonously moved on an optical axis
to an image surface side to thereby carry out the
variable power from the wide angle end to the
20 telescopic end. Reference symbol C designates a
compensator having a negative refracting power as a
third group. The compensator C is nonlinearly moved
on the optical axis to an object side while
describing a projection locus in order to compensate

for the fluctuation of an image surface following the variable power. The variator V and the compensator C constitute the variable power system.

Reference symbol SP designates a stop, and
5 reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol P designates a color separation prism, an optical filter or the like which is shown in the form of a
10 glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
15 with respect to the feature of the anamorphic converter AC in Numerical Example 2. The anamorphic converter AC includes: a first group G1 of lenses having a negative refracting power; a second group G2 of lenses having two cylindrical lenses; and a third
20 group G3 of lenses having an image formation function and a positive refracting power. Each of the cylindrical lenses belonging to the second group G2 has a curvature only in the Y direction, and has an effect of lengthening a focal length in the Y
25 direction. The aspect ratio AR1 of the image pickup range in the image surface of the imaging optical system, and the aspect ratio AR2 of the effective

area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (26)$$

$$AR2 = 1.78 \quad (27)$$

Also, the conversion magnification β_x in the X
5 direction, and the conversion magnification β_y in the
Y direction are as follows:

$$\beta_x = 0.947 \quad (28)$$

$$\beta_y = 1.252 \quad (29)$$

Consequently, the values of the conditional equations
10 are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (30)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 1.00 \quad (31)$$

Thus, these values meet the conditions of Equations 1
and 11. Consequently, the anamorphic converter of a
15 built-in converter system is attained which is
excellent in the optical performance and free from
the eclipse.

In addition, in case of the single anamorphic
converter AC, a focal length f_{ACx} in the X direction,
20 and a focal length f_{ACy} in the Y direction are
expressed as follows:

$$f_{ACx} = +36.688 \quad (32)$$

$$f_{ACy} = +81.334 \quad (33)$$

Thus, both of them have the positive refracting
25 powers and hence meet the condition which is required
for the anamorphic converter of the present invention.

FIGS. 8 to 14 are longitudinal aberration views

in the X direction or in the Y direction in Numerical
Example 2. In these figures, f_x indicates a focal
length in the X direction, f_y indicates a focal
length in the Y direction, F_x indicates an F number
5 in the X direction, F_y indicates an F number in the Y
direction, and 2ω indicates a field angle.

In Numerical Example 2, the following values
are obtained:

$f_x = 9.74$ to 142.93
10 $f_y = 12.88$ to 188.96
 $F_x = 1.94$ to 2.19
 $F_y = 2.56$ to 2.90
 $2\omega = 56.2$ to 4.2 degrees

15

r 1=	1169.481	d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429	d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	-265.170	d 3=	0.20				
r 4=	124.037	d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395	d 5=	0.20				
r 6=	51.797	d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915	d 7=	Variable				
r 8=	71.045	d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601	d 9=	6.01				
r10=	-21.542	d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397	d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134	d12=	Variable				
r13=	-27.245	d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613	d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345	d15=	Variable				
r16=	0.000	(Stop)	d16=	1.60			
r17=	10000.000		d17=	4.02	n10=	1.73234	v10= 54.7
r18=	-32.342		d18=	0.20			
r19=	107.938		d19=	3.60	n11=	1.48915	v11= 70.2
r20=	-121.402		d20=	0.20			
r21=	37.891		d21=	7.17	n12=	1.48915	v12= 70.2
r22=	-36.452		d22=	1.20	n13=	1.83932	v13= 37.2
r23=	177.431		d23=	30.00			
r24=	48.564		d24=	4.26	n14=	1.48915	v14= 70.2
r25=	-193.706		d25=	0.20			
r26=	-210.911		d26=	1.20	n15=	1.83932	v15= 37.2
r27=	39.960		d27=	6.49	n16=	1.48915	v16= 70.2
r28=	-33.683		d28=	0.20			
r29=	43.464		d29=	6.21	n17=	1.53430	v17= 48.8
r30=	-30.063		d30=	1.20	n18=	1.80811	v18= 46.6
r31=	113.246		d31=	0.20			
r32=	56.783		d32=	2.98	n19=	1.55098	v19= 45.8
r33=	-10000.000		d33=	2.40			
r34=	-406.116		d34=	1.30	n20=	1.88815	v20= 40.8
r35=	27.624		d35=	5.09			
r36=	-34.561		d36=	1.30	n21=	1.88815	v21= 40.8
r37=	376.875		d37=	2.39			
r38=	125.238		d38=	6.87	n22=	1.81264	v22= 25.4
r39=	-35.789		d39=	0.20			
r40=	51.579		d40=	5.00	n23=	1.73234	v23= 54.7
r41=	-179.240		d41=	10.68			
r42=	-89.456		d42=	1.50	n24=	1.83932	v24= 37.2
r43=	57.960		d43=	2.62			
r44=	56.863		d44=	8.20	n25=	1.48915	v25= 70.2
r45=	-31.532		d45=	1.30	n26=	1.81264	v26= 25.4
r46=	-88.322		d46=	0.20			
r47=	41.080		d47=	6.28	n27=	1.48915	v27= 70.2
r48=	-95.210		d48=	2.00			
r49=	0.000		d49=	30.00	n28=	1.60718	v28= 38.0
r50=	0.000		d50=	16.20	n29=	1.51825	v29= 64.2
r51=	0.000						

* r40 to r43 indicate the cylindrical lenses. A curvature in the X direction is zero.

Focal length fx	9.74	37.31	142.93
fy	12.88	49.33	188.96
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

(Third Embodiment)

This embodiment is concerned with an anamorphic
5 converter of a type having primary image formation.

FIG. 24 is a cross sectional view of lenses in
a Y direction and in an X direction when an
anamorphic converter is inserted in Numerical Example
3 of the present invention. In addition, a cross
10 sectional view before insertion of the anamorphic
converter in Numerical Example 3 is shown in FIG. 20.

In FIG. 24, reference symbol F designates a
group of front lenses having a positive refracting
power as a first group. Reference symbol V
15 designates a variator for the variable power having a
negative refracting power as a second group. The
variator V is monotonously moved on an optical axis
to an image surface side to thereby carry out the
variable power from the wide angle end to the
20 telescopic end. Reference symbol C designates a
compensator having a negative refracting power as a
third group. The compensator C is nonlinearly moved
on the optical axis to an object side while
describing a projection locus in order to compensate

for the fluctuation of an image surface following the variable power. The variator V and the compensator C constitute the variable power system.

Reference symbol SP designates a stop, and
5 reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol P designates a color separation prism, an optical filter or the like which is shown in the form of a
10 glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
15 with respect to the feature of the anamorphic converter AC in Numerical Example 3. The anamorphic converter AC includes: a first group G1 of lenses having a negative refracting power; a second group G2 of lenses having two cylindrical lenses; and a third
20 group G3 of lenses having an image formation function and a positive refracting power. Each of the cylindrical lenses belonging to the second group G2 has a curvature only in the Y direction, and has an effect of lengthening a focal length in the Y
25 direction. The aspect ratio AR1 of the image pickup range in the image surface of the imaging optical system, and the aspect ratio AR2 of the effective

area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (34)$$

$$AR2 = 1.78 \quad (35)$$

Also, the conversion magnification β_x in the X
5 direction, and the conversion magnification β_y in the
Y direction are as follows:

$$\beta_x = -0.947 \quad (36)$$

$$\beta_y = -1.252 \quad (37)$$

Consequently, the values of the conditional equations
10 are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (38)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 1.00 \quad (39)$$

Thus, these values meet the conditions of Equations 1
and 11. Consequently, the anamorphic converter of a
15 built-in converter system is attained which is
excellent in the optical performance and free from
the eclipse.

In addition, in case of the single anamorphic
converter AC, a focal length f_{ACx} in the X direction,
20 and a focal length f_{ACy} in the Y direction are
expressed as follows:

$$f_{ACx} = -684.6 \quad (40)$$

$$f_{ACy} = -1300.2 \quad (41)$$

Thus, they have large absolute values and small
25 refracting powers, nearly achieving telecentric on
the both sides.

FIGS. 25 to 30 are longitudinal aberration

views in the X direction or in the Y direction in
Numerical Example 3. In these figures, f_x indicates
a focal length in the X direction, f_y indicates a
focal length in the Y direction, F_x indicates an F
5 number in the X direction, F_y indicates an F number
in the Y direction, and 2ω indicates a field angle.

In Numerical Example 3, the following values
are obtained:

$f_x = -9.74$ to -142.93
10 $f_y = -12.88$ to -188.96
 $F_x = -1.94$ to -2.19
 $F_y = -2.56$ to -2.90
 $2\omega = 56.2$ to 4.2 degrees

r 1=	1169.481	d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429	d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	-265.170	d 3=	0.20				
r 4=	124.037	d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395	d 5=	0.20				
r 6=	51.797	d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915	d 7=	Variable				
r 8=	71.045	d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601	d 9=	6.01				
r10=	-21.542	d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397	d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134	d12=	Variable				
r13=	-27.245	d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613	d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345	d15=	Variable				
r16=	0.000	(Stop) d16=	1.60				
r17=	10000.000	d17=	4.02	n10=	1.73234	v10=	54.7
r18=	-32.342	d18=	0.20				
r19=	107.938	d19=	3.60	n11=	1.48915	v11=	70.2
r20=	-121.402	d20=	0.20				
r21=	37.891	d21=	7.17	n12=	1.48915	v12=	70.2
r22=	-36.452	d22=	1.20	n13=	1.83932	v13=	37.2
r23=	177.431	d23=	30.00				
r24=	48.564	d24=	4.26	n14=	1.48915	v14=	70.2
r25=	-193.706	d25=	0.20				
r26=	-210.911	d26=	1.20	n15=	1.83932	v15=	37.2
r27=	39.960	d27=	6.49	n16=	1.48915	v16=	70.2
r28=	-33.683	d28=	0.20				
r29=	43.464	d29=	6.21	n17=	1.53430	v17=	48.8
r30=	-30.063	d30=	1.20	n18=	1.80811	v18=	46.6
r31=	113.246	d31=	0.20				
r32=	56.783	d32=	2.98	n19=	1.55098	v19=	45.8
r33=	-10000.000	d33=	46.70				
r34=	-33.609	d34=	5.65	n20=	1.73234	v20=	54.7
r35=	-11.157	d35=	7.28				
r36=	-7.998	d36=	1.70	n21=	1.67765	v21=	32.1
r37=	58.541	d37=	9.27	n22=	1.62285	v22=	60.3
r38=	-14.431	d38=	20.48				
r39=	-158.737	d39=	0.54	n23=	1.69979	v23=	55.5
r40=	-48.696	d40=	0.15				
r41=	33-722	d41=	3.29	n24=	1.73234	v24=	54.7
r42=	-43.591	d42=	3.69				
r43=	-29.003	d43=	1.58	n25=	1.83932	v25=	37.2
r44=	52.354	d44=	3.63				
r45=	1000.000	d45=	1.70	n26=	1.52033	v26=	58.9
r46=	43.914	d46=	15.60				
r47=	-25.525	d47=	5.25	n27=	1.73234	v27=	54.7
r48=	-23.578	d48=	0.20				
r49=	59.012	d49=	13.97	n28=	1.49845	v28=	83.5
r50=	-22.890	d50=	1.70	n29=	1.83642	v29=	35.0

r51= -95.543 d51= 0.20
r52= 31.544 d52= 10.38 n30= 1.62286 v30= 60.3
r53= - d53= 6.55
1000.000
r54= 0.000 d54= 33.00 n31= 1.61170 v31= 46.4
r55= 0.000 d55= 13.20 n32= 1.51825 v32= 64.2
r56= 0.000 d56=

* r41 to r44 indicate the cylindrical lenses. A curvature in the X direction is zero.

Focal length fx	-9.74	-37.31	-142.93
fy	-12.88	-49.33	-188.96
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

As described above, in the anamorphic converter
5 disposed on an image side of the imaging optical
system, conversion magnifications of the cross
section X and the cross section Y containing an
optical axis are regulated and the lens structure is
appropriately set, whereby it is possible to attain
10 the anamorphic converter of the rear converter system
which is especially most suitable for a converter for
the cinema and excellent in optical performance.

(Operation 2)

Aspect 10

15 An anamorphic converter according to the
present invention includes at least an anamorphic
lens disposed on an image side of an imaging optical
system, and the anamorphic converter is characterized
in that when a focal length conversion magnification
20 in an arbitrary cross section X containing an optical

axis of the anamorphic converter is assigned βx , a focal length conversion magnification in a cross section Y containing an optical axis and being perpendicular to the cross section X is assigned βy ,
5 an aspect ratio of an image pickup range in an image surface of the imaging optical system is assigned AR1, and an aspect ratio of an effective area of image pickup means is assigned AR2, the following relationships are established:

10 $0.9 < (AR1 \times \beta x) / (AR2 \times \beta y) < 1.1 \quad (1)$

$$(AR2^2 + 1) \times \beta y^2 / (AR1^2 + 1) < 1 \quad (2)$$

Aspect 10 is concerned with a condition under which the conversion magnification of the anamorphic converter is suitably prescribed to thereby carry out
15 the suitable conversion of an aspect ratio without generation of an eclipse.

Equation 1 exhibits with a condition under which the suitable aspect ratio conversion is carried out. When as shown in FIG. 47, a transverse length
20 of an image surface is assigned X, a longitudinal length of the image surface is assigned Y, an aspect ratio AR is expressed by Equation 3:

$$AR = X/Y \quad (3)$$

A schematic diagram of an image pickup range of an
25 imaging optical system is shown in FIG. 48, and a schematic diagram of an image pickup range of an image pickup means is shown in FIG. 49. When from

FIG. 48, a transverse length of a size of an effective picture of the image pickup range in the image surface of the imaging optical system is assigned X_1 , a longitudinal length of the size of that effective picture is assigned Y_1 , and an aspect ratio is assigned AR_1 , and from FIG. 17, a transverse length of the image pickup range of the image pickup means is assigned X_2 , a longitudinal length of that image pickup range is assigned Y_2 , and an aspect ratio is assigned AR_2 , a ratio of AR_1/AR_2 is expressed by Equation 4:

$$AR_1/AR_2 = (X_1 \times Y_2)/(X_2 \times Y_1) \quad (4)$$

In addition, a conceptual diagram of an image pickup range after the conversion of the aspect ratio made by the anamorphic converter is shown in FIG. 50. In order that the aspect ratio may be suitably converted, it is desirable that a conversion magnifications β_x of the anamorphic converter in a transverse direction, and a conversion magnification β_y of the anamorphic converter in a longitudinal direction are expressed by Equations 5 and 6, respectively:

$$\beta_x = X_2/X_1 \quad (5)$$

$$\beta_y = Y_2/Y_1 \quad (6)$$

From Equations 6 to 8, the condition for ideal aspect ratio conversion is expressed as follows:

$$(AR_1 \times \beta_x)/(AR_2 \times \beta_y) = 1 \quad (7)$$

Since in actual, an influence of an error of about

10% is visually small, Equation 1 is met to thereby allow the suitable aspect ratio conversion to be realized.

Equation 2 exhibits a condition under which an
5 image pickup means having a width across corners smaller than an image size of the main lens is used. In a case where the converter is normally disposed on an image side of the main lens, a transverse aberration of the main lens is magnified at a
10 conversion magnification of the converter. In addition, since the image circle is regulated on the basis of an effective diameter on the main lens side, even if the conversion magnification is made smaller than 1, the promotion of the wide angle can not be
15 realized and hence the eclipse is generated in the periphery of the picture.

As shown in FIG. 48, the image circle I1 of the main lens is expressed by Equation 8:

$$\begin{aligned} I1 &= (X1^2 + Y1^2)^{1/2} \\ 20 \quad &= Y1 \times (AR1^2 + 1)^{1/2} \end{aligned} \quad (8)$$

In addition, as shown in FIG. 49, the width I2 across corners of the image pickup means is expressed by Equation (9):

$$\begin{aligned} I2 &= (X2^2 + Y2^2)^{1/2} \\ 25 \quad &= Y2 \times (AR2^2 + 1)^{1/2} \end{aligned} \quad (9)$$

As shown in FIG. 50, the width I3 across corners of the image an aspect ratio of which is converted by

the anamorphic converter is expressed as follows:

$$\begin{aligned} I_3 &= \{(\beta x \times X_1)^2 + (\beta y \times Y_1)^2\}^{1/2} \\ &= \beta y \times Y_1 \times (AR_2^2 + 1)^{1/2} \end{aligned} \quad (10)$$

Thus, in order that the width across corners of the
5 image after conversion of the aspect ratio may agree
with the image size of the main lens, a relationship
of $I_3 = I_1$ must be established. Consequently, from
Equations 8 and 10, Equations 11 and 11' are
obtained:

$$\begin{aligned} 10 \quad I_3^2/I_1^2 &= 1 \quad (11) \\ \{\beta y^2 \times (AR_2^2 + 1)\}/(AR_1^2 + 1) &= 1 \quad (11') \end{aligned}$$

Here, when the width I_2 across corners of the image
pickup means is smaller than the image size I_1 of the
main lens, even if a left number of Equation 11' is
15 smaller than 1, no eclipse is generated.

Consequently, Equation (2) is met, whereby it is
possible to attain the anamorphic converter most
suitable for a case where there is used the image
pickup means having a width across corners smaller
20 than the image size of the main lens. In addition,
since the conversion magnification of the converter
can be reduced, the magnification of the aberration
of the main lens can be suppressed to make the
optical performance excellent. Note that in the
25 present invention, the foregoing is also applied to a
case where the use conditions such as zooming,
focusing and a stopatic operation are restricted to

substantially magnify the image size of the main lens in using the optical system.

Moreover, a conceptual diagram of an output image in projecting an image is shown in FIG. 51. It is necessary that in projecting an image, the conversion of the aspect ratio reverse to that in capturing an image is carried out to return the current aspect ratio back to the original aspect ratio. Consequently, a transverse length X_4 and a longitudinal length Y_4 in FIG. 20 are expressed as follows, respectively:

$$X_4 = \beta_{x'} \times X_2 \quad (12)$$

$$Y_4 = \beta_{y'} \times Y_2 \quad (13)$$

Here, the conversion magnifications $\beta_{x'}$ and $\beta_{y'}$, when an arbitrary constant is assigned m , are expressed as follows, respectively:

$$\beta_{x'} = m/\beta_x \quad (14)$$

$$\beta_{y'} = m/\beta_y \quad (15)$$

Aspect 11

There is provided an anamorphic converter according to Aspect 10, in which the anamorphic lens is provided within an afocal group.

Aspect 12

There is provided an anamorphic converter according to Aspect 10 or 11, characterized in that both β_x and β_y are positive values, and the anamorphic converter has positive refracting powers

in the cross section X and in the cross section Y.

Aspect 13

There is provided an anamorphic converter according to Aspect 12, characterized in that the
5 anamorphic converter further includes, from the imaging optical system side in a stated order, a first group of lenses having a negative refracting power, a second group of lenses including at least two or more anamorphic lenses, and a third group of
10 lenses having a positive refracting power.

Aspect 12 is concerned with a condition under which the power disposition of the anamorphic converter for carrying out the aspect ratio conversion without the primary image formation by an
15 imaging optical system is suitably prescribed to make the optical performance excellent.

In order that the primary imaging may be prevented from being made, it is necessary that both the focal length conversion magnifications β_x and β_y
20 are positive values. Moreover, the cross section X and the cross section Y have positive refracting powers, respectively, to thereby reduce the effect of lengthening a focal length. As a result, there is obtained the anamorphic converter of a type having no
25 primary image formation in which for the single imaging optical system, the field angle is prevented from becoming too narrow, and the exit pupil can be

held for long.

In Aspect 13, the suitable structure in Aspect 12 is prescribed. In order that the cross section X and the cross section Y may have different conversion magnifications, it is necessary to form an afocal converter (anamorphic converter) having different angular magnifications in the cross section X and the cross section Y by using at least two so-called toric lenses each having different curvatures in the cross section X and the cross section Y, or at least two cylindrical lenses having a curvature in a certain cross section. In addition, in order that the converter may be disposed on an image side of the imaging optical system, there are required a first group of lenses having a negative refracting power for causing a converged ray from the imaging optical system to diverge, and a group of lenses having a positive refracting power for imaging that ray. Consequently, an optical property of a portion between the first group of lenses having a negative refracting power and the group of lenses having a positive refracting power is made nearly afocal, and a group of lenses including an anamorphic lens is introduced as the second group of lenses, whereby it is possible to attain an anamorphic converter having no primary image formation.

Aspect 14

There is provided an anamorphic converter according to Aspect 10 or 11, in which both β_x and β_y are negative values, and the anamorphic converter further includes at least one negative lens and two
5 or more anamorphic lenses.

Aspect 14 is concerned with a condition in which a structure of the anamorphic converter for obtaining the primary image formation through the imaging optical system to convert the aspect ratio is
10 suitably prescribed to make the optical performance excellent.

A conceptual view of the anamorphic converter of a type having primary image formation is shown in FIG. 64. For the optical system for reimaging the
15 primary image of the imaging optical system, it is necessary that both the focal length conversion magnifications β_x and β_y are negative values. In addition, in order to contain the marginal ray of the imaging optical system, it is necessary that an
20 entrance pupil nearly agrees with the exit pupil of the imaging optical system. Lenses for broadcasting including a lens for the digital cinema become an optical system which has a long exit pupil and hence is nearly telecentric on the image side since they
25 are established on the assumption that the color separation optical system is used. Consequently, at least an optical system which is nearly telecentric

on the both sides is required for the converter. As shown in FIG. 64, in case of the anamorphic converter of a type having primary image formation, since an emitted ray from the imaging optical system is made
5 nearly afocal using the positive lens, an increase in an off-axial chief ray emitted height hb_3 from the converter final surface is suppressed to prevent a quantity of marginal light from being reduced, and hence an off-axial chief ray emitted inclination
10 angle α_{b2} can be made small. As a result, there is an advantage that the exit pupil becomes long, and hence an influence of the color shading due to the color separation optical system is hardly generated. As shown in FIG. 64, from the condition in which the
15 converter is telecentric on the both sides, the anamorphic converter of a type having primary image formation is constituted by at least two groups of positive lenses, and the refracting power of the whole converter takes a minute value in the vicinity
20 of zero.

In addition, since for the primary image obtained through the imaging optical system, the various aberrations such as the chromatic aberration, the astigmatism and the curvature of field are
25 satisfactorily corrected, the chromatic aberration, the astigmatism, the curvature of field and the like of the converter must also be satisfactorily

corrected. When a refracting power of an i -th lens of lenses within the converter is assigned Φ_i , an Abbe's number of the i -th lens of the lenses is assigned v_i , and a refracting index of the i -th lens of the lenses is assigned N_i , a chromatic aberration correction condition is expressed as follows:

$$\Sigma(\Phi_i/v_i) \approx 0 \quad (16)$$

Also, a Petzval's condition is expressed as follows:

$$\Sigma(\Phi_i/N_i) \approx 0 \quad (17)$$

10 Here, since in the general optical materials, $v_i > 0$ and $N_i > 0$ are established, in order to meet Equations (16) and (17), the anamorphic converter having primary image formation must have at least a negative lens in terms of its structure. Moreover, 15 any one of the intervals within the converter is made nearly afocal, and the lens group including the above-mentioned anamorphic lens is introduced, whereby it is possible to attain the anamorphic converter of a primary image formation type.

20 Aspect 15

There is provided a lens device, including: the anamorphic converter according to any one of Embodiments 10 to 14; and the imaging optical system disposed on an object side with respect to the 25 anamorphic converter.

Aspect 16

There is provided an image pickup device,

including: the anamorphic converter according to any one of Aspects 10 to 15; an imaging optical system disposed on an object side with respect to the anamorphic converter; and image pickup means disposed
5 on the object side with respect to the anamorphic converter.

The anamorphic lens used in the present invention is used in terms of the concept including a toric lens and a cylindrical lens, and hence means a
10 lens in which a power in the X direction is different from that in the Y direction.

In addition, the anamorphic lens used in the present invention may have a function of a diffraction system.

15 Moreover, the imaging optical system of the present invention may be a variable power system or a fixed power system (having no variable power).

(Fourth Embodiment)

This embodiment is concerned with an anamorphic
20 converter of a type having no primary image formation.

A specific structure of the anamorphic converter according to the present invention is described next. FIG. 33 is a cross sectional view of lenses in a Y direction and in an X direction when an
25 anamorphic converter is inserted in Numerical Example 4 of the present invention. In addition, a cross sectional view before insertion of the anamorphic

converter in Numerical Example 4 is shown in FIG. 52.

FIGS. 53 to 55 show longitudinal aberration views before insertion of the anamorphic converter in Numerical Examples 4, 5, and 6, respectively.

5 In FIG. 33, reference symbol F designates a group of front lenses having a positive refracting power as a first group. Reference symbol V designates a variator for the variable power having a negative refracting power as a second group. The
10 variator V is monotonously moved on an optical axis to an image surface side to thereby carry out the variable power from the wide angle end to the telescopic end. Reference symbol C designates a compensator having a negative refracting power as a
15 third group. The compensator C is nonlinearly moved on the optical axis to an object side while describing a projection locus in order to compensate for the fluctuation of an image surface following the variable power. The variator V and the compensator C
20 constitute the variable power system.

 Reference symbol SP designates a stop, and reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol
25 P designates a color separation prism, an optical filter or the like which is shown in the form of a glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
5 with respect to the feature of the anamorphic
converter AC in Numerical Example 4. The anamorphic
converter AC includes: a first group G1 of lenses
having a negative refracting power; a second group G2
of lenses having two cylindrical lenses; and a third
10 group G3 of lenses having an image formation function
and a positive refracting power. Each of the
cylindrical lenses belonging to the second group G2
has a curvature only in the X direction, and has an
effect of shortening a focal length in the X
15 direction. The aspect ratio AR1 of the image pickup
range in the image surface of the imaging optical
system, and the aspect ratio AR2 of the effective
area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (18)$$

20 $AR2 = 1.78 \quad (19)$

Also, the conversion magnification β_x in the X
direction, and the conversion magnification β_y in the
Y direction are as follows:

$$\beta_x = 0.767 \quad (20)$$

25 $\beta_y = 1.013 \quad (21)$

Consequently, the values of the conditional equations
are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (22)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 0.656 \quad (23)$$

Thus, these values meet the conditions of Equations 1 and 2. Consequently, the anamorphic converter of a built-in converter system is attained which is excellent in the optical performance and free from the eclipse.

In addition, in case of the single anamorphic converter AC, a focal length f_{ACx} in the X direction, and a focal length f_{ACy} in the Y direction are expressed as follows:

$$f_{ACx} = +23.383 \quad (24)$$

$$f_{ACy} = +40.894 \quad (25)$$

Thus, both of them have the positive refracting powers and hence meet the condition which is required for the anamorphic converter of the present invention.

A material of the cylindrical lens used in this embodiment is glass. In the following fifth and sixth embodiments as well, the same material will be used.

FIGS. 34 to 39 are longitudinal aberration views in the X direction or in the Y direction in Numerical Example 4. In these figures, f_x indicates a focal length in the X direction, f_y indicates a focal length in the Y direction, F_x indicates an F number in the X direction, F_y indicates an F number in the Y direction, and 2ω indicates a field angle.

In Numerical Example 4, the following values
are obtained:

$$f_x = 7.90 \text{ to } 115.83$$

$$f_y = 10.44 \text{ to } 153.12$$

5 $F_x = 1.57 \text{ to } 1.78$

$$F_y = 2.08 \text{ to } 2.35$$

$$2\omega = 56.2 \text{ to } 4.2 \text{ degrees}$$

r 1=	1169.481	d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429	d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	-265.170	d 3=	0.20				
r 4=	124.037	d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395	d 5=	0.20				
r 6=	51.797	d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915	d 7=	Variable				
r 8=	71.045	d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601	d 9=	6.01				
r10=	-21.542	d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397	d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134	d12=	Variable				
r13=	-27.245	d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613	d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345	d15=	Variable				
r16=	0.000	(Stop)	d16=	1.60			
r17=	10000.000		d17=	4.02	n10=	1.73234	v10= 54.7
r18=	-32.342		d18=	0.20			
r19=	107.938		d19=	3.60	n11=	1.48915	v11= 70.2
r20=	-121.402		d20=	0.20			
r21=	37.891		d21=	7.17	n12=	1.48915	v12= 70.2
r22=	-36.452		d22=	1.20	n13=	1.83932	v13= 37.2
r23=	177.431		d23=	30.00			
r24=	48.564		d24=	4.26	n14=	1.48915	v14= 70.2
r25=	-193.706		d25=	0.20			
r26=	-210.911		d26=	1.20	n15=	1.83932	v15= 37.2
r27=	39.960		d27=	6.49	n16=	1.48915	v16= 70.2
r28=	-33.683		d28=	0.20			
r29=	43.464		d29=	6.21	n17=	1.53430	v17= 48.8
r30=	-30.063		d30=	1.20	n18=	1.80811	v18= 46.6
r31=	113.246		d31=	0.20			
r32=	56.783		d32=	2.98	n19=	1.55098	v19= 45.8
r33=	-10000.000		d33=	2.40			
r34=	-7839.440		d34=	1.50	n20=	1.88815	v20= 40.8
r35=	23.812		d35=	11.72			
r36=	-53.891		d36=	1.50	n21=	1.88815	v21= 40.8
r37=	-398.617		d37=	0.20			
r38=	70.482		d38=	5.77	n22=	1.81264	v22= 25.4
r39=	-44.050		d39=	0.31			
r40=	-53.902		d40=	1.50	n23=	1.51825	v23= 64.1
r41=	63.160		d41=	13.62			
r42=	128.438		d42=	4.68	n24=	1.88815	v24= 40.8
r43=	-80.144		d43=	0.20			
r44=	29.500		d44=	8.88	n25=	1.48915	v25= 70.2
r45=	-24.900		d45=	1.50	n26=	1.81264	v26= 25.4
r46=	250.300		d46=	0.20			
r47=	139.800		d47=	5.28	n27=	1.48915	v27= 70.2
r48=	-32.300		d48=	2.00			
r49=	0.000		d49=	29.00	n28=	1.60718	v28= 38.0
r50=	0.000		d50=	11.20	n29=	1.51825	v29= 64.2
r51=	0.000						

* r40 to r43 indicate the cylindrical lenses. A curvature in the Y direction is zero.

Focal length fx	7.9	30.24	115.83
fy	10.44	39.98	153.12
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

(Fifth Embodiment)

This embodiment is concerned with an anamorphic
5 converter of a type having no primary image formation.

FIG. 40 is a cross sectional view of lenses in
a Y direction and in an X direction when an
anamorphic converter is inserted in Numerical Example
5 of the present invention. In addition, a cross
10 sectional view before insertion of the anamorphic
converter in Numerical Example 5 is shown in FIG. 52.

In FIG. 40, reference symbol F designates a
group of front lenses having a positive refracting
power as a first group. Reference symbol V
15 designates a variator for the variable power having a
negative refracting power as a second group. The
variator V is monotonously moved on an optical axis
to an image surface side to thereby carry out the
variable power from the wide angle end to the
20 telescopic end. Reference symbol C designates a
compensator having a negative refracting power as a
third group. The compensator C is nonlinearly moved
on the optical axis to an object side while
describing a projection locus in order to compensate

for the fluctuation of an image surface following the variable power. The variator V and the compensator C constitute the variable power system.

Reference symbol SP designates a stop, and
5 reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol P designates a color separation prism, an optical filter or the like which is shown in the form of a
10 glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
15 with respect to the feature of the anamorphic converter AC in Numerical Example 5. The anamorphic converter AC includes: a first group G1 of lenses having a negative refracting power; a second group G2 of lenses having two cylindrical lenses; and a third
20 group G3 of lenses having an image formation function and a positive refracting power. Each of the cylindrical lenses belonging to the second group G2 has a curvature only in the Y direction, and has an effect of lengthening a focal length in the Y
25 direction. The aspect ratio AR1 of the image pickup range in the image surface of the imaging optical system, and the aspect ratio AR2 of the effective

area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (26)$$

$$AR2 = 1.78 \quad (27)$$

Also, the conversion magnification β_x in the X
5 direction, and the conversion magnification β_y in the
Y direction are as follows:

$$\beta_x = 0.713 \quad (28)$$

$$\beta_y = 0.942 \quad (29)$$

Consequently, the values of the conditional equations
10 are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (30)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 0.567 \quad (31)$$

Thus, these values meet the conditions of Equations 1
and 2. Consequently, the anamorphic converter of a
15 built-in converter system is attained which is
excellent in the optical performance and free from
the eclipse.

In addition, in case of the single anamorphic
converter AC, a focal length f_{ACx} in the X direction,
20 and a focal length f_{ACy} in the Y direction are
expressed as follows:

$$f_{ACx} = +22.999 \quad (32)$$

$$f_{ACy} = +38.486 \quad (33)$$

Thus, both of them have the positive refracting
25 powers and hence meet the condition which is required
for the anamorphic converter of the present invention.

FIGS. 40 to 46 are longitudinal aberration

views in the X direction or in the Y direction in
Numerical Example 5. In these figures, f_x indicates
a focal length in the X direction, f_y indicates a
focal length in the Y direction, F_x indicates an F
5 number in the X direction, F_y indicates an F number
in the Y direction, and 2ω indicates a field angle.

In Numerical Example 5, the following values
are obtained:

10 $f_x = 7.34$ to 107.72
 $f_y = 9.71$ to 142.41
 $F_x = 1.46$ to 1.65
 $F_y = 1.93$ to 2.19
 $2\omega = 56.2$ to 4.2 degrees

r 1=	1169.481		d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429		d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	-265.170		d 3=	0.20				
r 4=	124.037		d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395		d 5=	0.20				
r 6=	51.797		d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915		d 7=	Variable				
r 8=	71.045		d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601		d 9=	6.01				
r10=	-21.542		d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397		d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134		d12=	Variable				
r13=	-27.245		d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613		d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345		d15=	Variable				
r16=	0.000	(Stop)	d16=	1.60				
r17=	10000.000		d17=	4.02	n10=	1.73234	v10=	54.7
r18=	-32.342		d18=	0.20				
r19=	107.938		d19=	3.60	n11=	1.48915	v11=	70.2
r20=	-121.402		d20=	0.20				
r21=	37.891		d21=	7.17	n12=	1.48915	v12=	70.2
r22=	-36.452		d22=	1.20	n13=	1.83932	v13=	37.2
r23=	177.431		d23=	30.00				
r24=	48.564		d24=	4.26	n14=	1.48915	v14=	70.2
r25=	-193.706		d25=	0.20				
r26=	-210.911		d26=	1.20	n15=	1.83932	v15=	37.2
r27=	39.960		d27=	6.49	n16=	1.48915	v16=	70.2
r28=	-33.683		d28=	0.20				
r29=	43.464		d29=	6.21	n17=	1.53430	v17=	48.8
r30=	-30.063		d30=	1.20	n18=	1.80811	v18=	46.6
r31=	113.246		d31=	0.20				
r32=	56.783		d32=	2.98	n19=	1.55098	v19=	45.8
r33=	-10000.000		d33=	2.40				
r34=	-406.116		d34=	1.50	n20=	1.88815	v20=	40.8
r35=	27.624		d35=	5.09				
r36=	-34.561		d36=	1.30	n21=	1.88815	v21=	40.8
r37=	376.875		d37=	2.39				
r38=	125.238		d38=	6.87	n22=	1.81264	v22=	25.4
r39=	-35.789		d39=	0.20				
r40=	51.579		d40=	5.00	n23=	1.73234	v23=	54.7
r41=	-179.240		d41=	10.68				
r42=	-89.456		d42=	1.50	n24=	1.89932	v24=	37.2
r43=	57.960		d43=	2.62				
r44=	42.100		d44=	8.20	n25=	1.48915	v25=	70.2
r45=	-23.300		d45=	1.30	n26=	1.81264	v26=	25.4
r46=	-85.300		d46=	0.20				
r47=	30.400		d47=	6.28	n27=	1.48915	v27=	70.2
r48=	-70.400		d48=	0.50				
r49=	0.000		d49=	29.00	n28=	1.60718	v28=	38.0
r50=	0.000		d50=	11.20	n29=	1.51825	v29=	64.2
r51=	0.000							

* r40 to r43 indicate the cylindrical lenses. A curvature in the X direction is zero.

Focal length fx	7.34	28.12	107.72
fy	9.71	37.18	142.41
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

(Sixth Embodiment)

This embodiment is concerned with an anamorphic
5 converter of a type having no primary image formation.

FIG. 56 is a cross sectional view of lenses in
a Y direction and in an X direction when an
anamorphic converter is inserted in Numerical Example
6 of the present invention. In addition, a cross
10 sectional view before insertion of the anamorphic
converter in Numerical Example 6 is shown in FIG. 52.

In FIG. 56, reference symbol F designates a
group of front lenses having a positive refracting
power as a first group. Reference symbol V
15 designates a variator for the variable power having a
negative refracting power as a second group. The
variator V is monotonously moved on an optical axis
to an image surface side to thereby carry out the
variable power from the wide angle end to the
20 telescopic end. Reference symbol C designates a
compensator having a negative refracting power as a
third group. The compensator C is nonlinearly moved
on the optical axis to an object side while
describing a projection locus in order to compensate

for the fluctuation of an image surface following the variable power. The variator V and the compensator C constitute the variable power system.

Reference symbol SP designates a stop, and
5 reference symbol R designates a group of variable power semi-fixed relay lenses having a positive refracting power as a fourth group. Reference symbol P designates a color separation prism, an optical filter or the like which is shown in the form of a
10 glass block in the figure.

The focusing group F, the variator V, the compensator C and the relay group R constitute an imaging optical system.

Next, a description will hereinafter be given
15 with respect to the feature of the anamorphic converter AC in Numerical Example 6. The anamorphic converter AC includes: a first group G1 of lenses having a negative refracting power; a second group G2 of lenses having two cylindrical lenses; and a third
20 group G3 of lenses having an image formation function and a positive refracting power. Each of the cylindrical lenses belonging to the second group G2 has a curvature only in the Y direction, and has an effect of lengthening a focal length in the Y
25 direction. The aspect ratio AR1 of the image pickup range in the image surface of the imaging optical system, and the aspect ratio AR2 of the effective

area of the image pickup means are as follows:

$$AR1 = 2.35 \quad (34)$$

$$AR2 = 1.78 \quad (35)$$

Also, the conversion magnification β_x in the X
5 direction, and the conversion magnification β_y in the
Y direction are as follows:

$$\beta_x = -0.691 \quad (36)$$

$$\beta_y = -0.913 \quad (37)$$

Consequently, the values of the conditional equations
10 are obtained as follows:

$$(AR1 \times \beta_x) / (AR2 \times \beta_y) = 1.00 \quad (38)$$

$$(AR2^2 + 1) \times \beta_y^2 / (AR1^2 + 1) = 0.533 \quad (39)$$

Thus, these values meet the conditions of Equations 1
and 11. Consequently, the anamorphic converter of a
15 built-in converter system is attained which is
excellent in the optical performance and free from
the eclipse.

In addition, in case of the single anamorphic
converter AC, a focal length f_{ACx} in the X direction,
20 and a focal length f_{ACy} in the Y direction are
expressed as follows:

$$f_{ACx} = -88.42 \quad (40)$$

$$f_{ACy} = -123.52 \quad (41)$$

Thus, they have large absolute values and small
25 refracting powers, nearly achieving telecentric on
the both sides.

FIGS. 56 to 62 are longitudinal aberration

views in the X direction or in the Y direction in
Numerical Example 6. In these figures, f_x indicates
a focal length in the X direction, f_y indicates a
focal length in the Y direction, F_x indicates an F
5 number in the X direction, F_y indicates an F number
in the Y direction, and 2ω indicates a field angle.

In Numerical Example 6, the following values
are obtained:

10 $f_x = -7.11$ to -104.37
 $f_y = -9.40$ to -137.96
 $F_x = -1.42$ to -1.60
 $F_y = -1.87$ to -2.12
 $2\omega = 56.2$ to 4.2 degrees

r 1=	1169.481		d 1=	2.40	n 1=	1.81265	v 1=	25.4
r 2=	98.429		d 2=	10.83	n 2=	1.51825	v 2=	64.2
r 3=	-265.170		d 3=	0.20				
r 4=	124.037		d 4=	8.29	n 3=	1.60548	v 3=	60.7
r 5=	-281.395		d 5=	0.20				
r 6=	51.797		d 6=	6.46	n 4=	1.64254	v 4=	60.1
r 7=	97.915		d 7=	Variable				
r 8=	71.045		d 8=	0.90	n 5=	1.82017	v 5=	46.6
r 9=	17.601		d 9=	6.01				
r10=	-21.542		d10=	0.90	n 6=	1.77621	v 6=	49.6
r11=	18.397		d11=	4.63	n 7=	1.85501	v 7=	23.9
r12=	-4295.134		d12=	Variable				
r13=	-27.245		d13=	0.90	n 8=	1.79013	v 8=	44.2
r14=	31.613		d14=	3.84	n 9=	1.85501	v 9=	23.9
r15=	1125.345		d15=	Variable				
r16=	0.000	(Stop)	d16=	1.60				
r17=	10000.000		d17=	4.02	n10=	1.73234	v10=	54.7
r18=	-32.342		d18=	0.20				
r19=	107.938		d19=	3.60	n11=	1.48915	v11=	70.2
r20=	-121.402		d20=	0.20				
r21=	37.891		d21=	7.17	n12=	1.48915	v12=	70.2
r22=	-38.452		d22=	1.20	n13=	1.83932	v13=	37.2
r23=	177.431		d23=	30.00				
r24=	48.564		d24=	4.26	n14=	1.48915	v14=	70.2
r25=	-193.706		d25=	0.20				
r26=	-210.911		d26=	1.20	n15=	1.83932	v15=	37.2
r27=	39.960		d27=	6.49	n16=	1.48915	v16=	70.2
r28=	-33.683		d28=	0.20				
r29=	43.464		d29=	6.21	n17=	1.53430	v17=	48.8
r30=	-30.063		d30=	1.20	n18=	1.80811	v18=	46.6
r31=	113.246		d31=	0.20				
r32=	56.783		d32=	2.98	n19=	1.55098	v19=	45.8
r33=	-10000.000		d33=	46.70				
r34=	-39.609		d34=	5.65	n20=	1.73234	v20=	54.7
r35=	-11.167		d35=	7.28				
r36=	-7.998		d36=	1.70	n21=	1.67765	v21=	32.1
r37=	58.541		d37=	9.27	n22=	1.62286	v22=	60.3
r38=	-14.491		d38=	20.48				
r39=	-150.787		d39=	4.54	n23=	1.69979	v23=	55.5
r40=	-40.896		d40=	0.15				
r41=	36.722		d41=	9.29	n24=	1.73234	v24=	54.7
r42=	-43.594		d42=	3.69				
r43=	-29.003		d43=	1.58	n25=	1.83932	v25=	37.2
r44=	52.354		d44=	3.68				
r45=	800.000		d45=	1.70	n26=	1.52033	v26=	58.9
r46=	40.000		d46=	16.60				
r47=	-21.200		d47=	5.25	n27=	1.73234	v27=	54.7
r48=	-18.900		d48=	0.20				
r49=	47.200		d49=	13.97	n28=	1.49845	v28=	81.5
r50=	-18.300		d50=	1.70	n29=	1.80642	v29=	35.0

r51= -76.400 d51= 0.20
r52= 25.200 d52= 10.38 n30= 1.62286 v30= 60.3
r53= -800.000 d53= 1.00
r54= 0.000 d54= 29.00 n31= 1.60718 v31= 38.0
r55= 0.000 d55= 11.20 n32= 1.51825 v32= 64.2
r56= 0.000

* r41 to r44 indicate the cylindrical lenses. A curvature in the X direction is zero.

Focal length fx	-7.11	-27.25	-104.37
fy	-9.4	-36.02	-137.96
Variable spacing			
d7	0.39	33.92	49.55
d12	52.91	14.8	3.78
d15	1.55	6.13	1.53

5 As described above, in the anamorphic converter disposed on an image side of the imaging optical system, conversion magnifications of the cross section X and the cross section Y containing an optical axis are regulated and the lens structure is
10 appropriately set, whereby it is possible to attain the anamorphic converter of the rear converter system which is especially most suitable for a converter for the cinema and excellent in optical performance for using the image pickup means having a width across
15 corners smaller than an image size of the imaging optical system.